DECLARATION

I, Seiichi Kuwai, residing at 7-17-5, Okusawa, Setagaya-ku, Tokyo, Japan hereby certify that I am the translator of the attached document, namely, the certified copy of Japanese Patent Application No. 2001-087643, and I certify that the followings are true translation thereof to the best of my knowledge and belief.

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PATENT OFFICE
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This is to certify that the annexed is a true copy of the following application as filed in this office.

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[TITLE OF THE INVENTION]

Ball Transfer Apparatus and Ball Arraying Apparatus

[SCOPE OF CLAIM FOR PATENT]

[Claim 1] A ball transfer apparatus for transferring balls onto electrode pads of a substrate, characterized by comprising

a ball arraying pallet formed with arraying holes for arraying said balls at positions corresponding to said electrode pads of said substrate,

an arraying pallet table on, which said ball arraying pallet, is mounted,

a ball sucking plate formed with sucking holes corresponding to said arraying holes formed in said ball arraying pallet, and

a ball sucking base plate connected to said ball sucking plate and formed with a vacuum sucking passage and sucking holes in such a manner as to suck from said sucking holes in vacuum,

and in that

said arraying holes are covered with said ball sucking plate in such a manner as to be tightly sealed therewith when said balls arrayed in said ball arraying pallet are sucked to said ball sucking plate.

[Claim 2] The ball transfer apparatus as set forth in claim 1, in which said ball arraying pallet is further formed with sucking holes connected to the bottoms of said arraying holes.

[Claim 3] The ball transfer apparatus as set forth in claim 2, in which said sucking holes are formed in such a manner as to be offset from said arraying holes in said ball arraying pallet.

[Claim 4] The ball transfer apparatus as set forth in claim 3, in which said sucking plate sucks said balls under the condition that the sucking holes are offset from said arraying holes.

[Claim 5] The ball transfer apparatus as set forth in claim 3 or 4, in which said ball arraying pallet is formed by a first component member formed with said arraying holes and a second component member formed with said sucking holes.

[Claim 6] The ball transfer apparatus as set forth in claim 5, in which said first component member is connected to said second component member through a diffusion bonding.

[Claim 7] The ball transfer apparatus as set forth in claim any one of claims 1 to 6, in which the depth of said arraying holes in said ball arraying pallet has a ratio equal to or greater than 0.5 and equal to or less than 1.1 with respect to the diameter of said balls.

[Claim 8] The ball transfer apparatus as set forth in claim 1, in which ball escaping holes are formed in the bottom portions of said ball sucking plate so that said balls are prevented from interference.

[Claim 9] The ball transfer apparatus as set forth in claim 8, in which said ball sucking plate is formed by a first component member formed with said sucking holes and a second component member formed with said ball escaping holes.

[Claim 10] The ball transfer apparatus as set forth in claim 9, in which said first component

member and said second component member are connected to each other through a diffusion bonding.

[Claim 11] The ball transfer apparatus as set forth in any one of claims 8 to 10, in which said ball escaping holes have predetermined slopes, respectively.

[Claim 12] The ball transfer apparatus as set forth in claim 11, in which said slopes are formed of silicon.

[Claim 13] The ball transfer apparatus as set forth in claim 12, in which said slopes are formed by (111) plane of said silicon.

[Claim 14] The ball transfer apparatus as set forth in any one of claims 8 to 10, in which predetermined curved surfaces are formed for said ball escaping holes.

[Claim 15] The ball transfer apparatus as set forth in claim 14, in which said curved surfaces are formed through an electroforming process.

[Claim 16] The ball transfer apparatus as set forth in claim 14, in which said curved surfaces are formed by organic layers.

[Claim 17] The ball transfer apparatus as set forth in claim 16, in which said organic layers are formed of at least one material selected from the group consisting of polyimide, polyamide or polyurea resin.

[Claim 18] The ball transfer apparatus as set forth in claim 1, in which a vibration imparting means is provided to said ball arraying pallet table so as to give rise to vibrations of said ball arraying pallet.

[Claim 19] The ball transfer apparatus as set forth in claim 18, in which said vibration imparting means is formed by a piezoelectric element.

[Claim 20] The ball transfer apparatus as set forth in any one of claims 1 to 19, in which an image pickup means is provided to take an image of said ball arraying pallet, thereby monitoring to see whether or not there are said balls.

[Claim 21] The ball transfer apparatus as set forth in claim 20, in which a region where there are said balls without trouble is selected through said image pickup means.

[Claim 22] A ball arraying apparatus for dipping a ball arraying pallet formed with arraying holes for arraying balls at positions corresponding to electrode pads on a substrate in conductive liquid in a bath,

characterized in that sucking holes are formed in such a manner as to be connected to the bottoms of said arraying holes.

[Claim 23] The ball arraying pallet characterized by comprising a ball arraying pallet formed with arraying holes for arraying balls at positions corresponding to electrode pads on a substrate and a ball supplying device for concurrently supplying said balls and conductive liquid onto said ball arraying pallet.

[Claim 24] The ball arraying apparatus as set forth in claim 22 or claim 23, in which said sucking holes are formed in said ball arraying pallet in such a manner that said sucking holes are offset from said arraying holes.

[Claim 25] The ball arraying apparatus as set forth in any one of claims 22 to 24, in which said ball arraying pallet is formed through a technique in which a first component member formed with said arraying holes is bonded to a second component member formed with said sucking holes.

[Claim 26] The ball arraying apparatus as set forth in claim 25, in which said first component member and said second component member are connected to each other through a diffusion bonding.

[DETAILED DESCRIPTION OF THE INVENTION]

[0001]

[TECHNICAL FIELD OF THE INVENTION]

The present invention relates to a flip chip bonding and a bump technique for a ball grid array etc., and, more particular, to a ball transfer apparatus for transferring conductive balls of solder or gold onto a semiconductor chip or a printed substrate.

[0002]

[PRIOR ART]

In a semiconductor chip assembling process, conductive balls such as solder balls are arrayed for flip chip packages, chip size packages (CSP) and ball grid array packages (BGA).

[0003]

A ball arraying method, in which balls are released from a ball sucking plate formed with sucking holes at positions corresponding to electrode pads of a printed substrate through an etching or an electroforming into which the balls have been sucked in vacuum, whereby the balls are arrayed on the electrode pads for producing bumps, has been developed and commercially used.

[0004]

As to a method for sucking the balls into the ball sucking plate, it is known that the conductive balls, which are randomly positioned, are sucked. However, it is difficult to surely suck them, because the positions of the conductive balls to be sucked are unstable.

[0005]

[PROBLEMS TO BE SOLVED BY THE INVENTION]

The applicants have proposed a ball transferring method improved in surely sucking the balls into the sucking head in Japanese Patent Application No. Hei 11-311866, (which is hereinafter referred to as "related application").

[0006]

As described in the related application, the conductive balls are sucked from a pallet where the conductive balls have been held at predetermined positions same as those of the ball sucking plate, whereby the certainty of the ball sucking is enhanced.

[0007]

Semiconductor chips have been further miniaturized, and the conductive balls are getting smaller and smaller so that the conductive balls, which have been held in the arraying holes of the arraying pallet, are hardly sucked into the ball sucking plate when the conductive balls are captured on the bottoms or walls of the arraying holes.

[0008]

If the captured balls are forced to be separated in strong sucking pressure, there is a problem in that the balls become rather unstable due to the large impact in the sucking holes at the sucking.

[0009]

In the related application, it was proposed that the conductive balls are forcibly separated from the bottoms and walls of the arraying holes by blowing gas from the bottoms of the arraying holes of the arraying pallet in the method proposed therein.

[0010]

However, it is difficult to optimize the pressure of the gas to be blown from the bottoms of the arraying holes under the condition that the balls are further miniaturized; if the pressure is weak, the conductive balls are hardly separated, if the pressure is too strong, the balls are deformed after being blown off..

[0011]

Since the semiconductor chips are miniaturized, there is a tendency that the pitches of the electrode pads become short; it becomes impossible to ignore the problem that the adjacent balls are mutually electrostatically influential. When the balls are sucked in the sucking pallet, there is a problem in that the balls are hardly received in the sucking holes, because the balls are electrostatically attracted.

[0012]

The present invention is made in the contemplation for the above described problems, and an object is to surely smoothly transfer balls received in an arraying pallet to electrode pads of a semiconductor chip without any excess ball or shortage of ball.

[0013]

[MEANS TO SOLVE THE PROBLEMS]

To accomplish the object, there is provided a ball transfer apparatus characterized by

comprising a ball arraying pallet formed with arraying holes for arraying balls at positions corresponding to electrode pads of a substrate, an arraying pallet table on which the ball arraying pallet is mounted, a ball sucking plate formed with sucking holes corresponding to the arraying holes formed in the ball arraying pallet and a ball sucking base plate connected to the ball sucking plate and formed with a vacuum sucking passage and sucking holes in such a manner as to suck from the sucking holes in vacuum, wherein the arraying holes are covered with the ball sucking plate in such a manner as to be tightly sealed therewith when the balls arrayed in the ball arraying pallet are sucked to the ball sucking plate.

[0014]

It is desirable that the ball arraying pallet is further formed with sucking holes connected to the bottoms of the arraying holes.

[0015]

It is desirable that the sucking holes are formed in such a manner as to be offset from the arraying holes in the ball arraying pallet, and plural sucking holes may be provided for each of the arraying holes. The plural sucking holes may be arranged around a center of each arraying hole.

[0016]

It is desirable that the sucking plate sucks the balls under the condition that the sucking holes are offset from the arraying holes.

[0017]

The ball arraying pallet may be formed by a first component member formed with the arraying holes and a second component member formed the said sucking holes.

[0018]

The first component member is connected to the second component member through a diffusion bonding.

[0019]

It is desirable that the depth of the arraying holes in the ball arraying pallet has a ratio equal to or greater than 0.5 and equal to or less than 1.1 with respect to the diameter of the balls.

[0020]

It is further desirable that ball escaping holes are formed in the bottom portions of the ball sucking plate so that the balls are prevented from interference.

[0021]

The ball sucking plate may be formed by a first component member formed with the sucking holes and a second component member formed with the ball escaping holes.

[0022]

It is desirable that the first component member and the second component member are connected to each other with any assistance of organic bonding compound, and it is desirable to use a diffusion

bonding. When the first and second component members are formed by silicon layers or a combination between a glass layer and a silicon layer, an electrostatic bonding is desirable.

[0023]

Although any contour of the escaping portions is employable in so far as the balls are tightly sealed when it is combined with the arraying holes, it is desirable to make the escaping portions large in order to absorb the dispersion in the machining accuracy between the ball arraying pallet and the ball sucking plate and the dispersion in the assemblage between the ball arraying pallet and the ball sucking plate.

[0024]

A plurality of second component members, which are formed with escaping portions different in contour from one another, are prepared, and are bonded to each other so as to form a terraced escaping portion, whereby the ball is leaded to the sucking hole in the sucking.

[0025]

The escaping portion may be formed by slops. As to a method for forming the slopes, it is desirable to use an anisotropic etching on silicon layers. (111) plane of silicon form a quadrangular pyramid, which serves as the escaping portion, and are desirable, because the slopes are equal to one another.

[0026]

The escaping portion may be formed by a curved surface. As to a method for forming the curved surface, it is desirable to precipitate metal phase on the escaping portion already formed through an electroforming or form an organic layer thereon.

[0027]

It is desirable to use the electroforming, through which the precipitated phase is formed on the escaping portion already formed, whereby a curved surface is formed around the corner of the escaping portion.

[0028]

As to the method for forming an organic layer, a ball sucking plate, in which the escaping portion has been already formed, is put in a vacuum furnace, then, vacuum is developed in the furnace, thereafter, precursor of polyimide, polyamide or polyurea resin is introduced into the furnace so as to form polymer through the heating.

[0029]

Using this method, it is possible to not only control the thickness of the organic layer but also uniformly form the organic layer on the surface of the escaping portion and side surface of an escaping hole, whereby uniform curved surface is formed on the escaping portion.

[0030]

It is desirable to provide a vibration imparting means the ball arraying pallet table so as to give rise

to vibrations of the ball arraying pallet.

[0031]

It is desirable to use a piezoelectric element as the vibration imparting means.

[0032]

An image pickup means is desirably provided to take an image of said ball arraying pallet so as to monitor it to see whether or not there are the balls.

[0033]

[OPERATION]

According to the present invention, when the conductive balls, which are arrayed in the ball arraying pallet, are sucked in vacuum into the ball sucking plate, the arraying holes in the ball arraying pallet are tightly closed with the ball sucking plate.

[0034]

As a result, the efficiency to suck the conductive balls is enhanced, and the air flow, which is produced in the vacuum sucking by connecting the sucking holes to the bottoms of the arraying holes, makes the balls surely sucked.

[0035]

Moreover, since the adjacent spaces are partitioned through the tight sealing, it is possible to prevent the balls from the interference due to the electrostatic charges.

[0036]

Since the sucking holes, which are provided in the bottom portions of the arraying holes, are disposed in an offset manner to the arraying holes, the balls are made stable. A plurality of sucking holes may be formed for each of the arraying holes, and the plurality of sucking holes may be arranged around the center of each arraying hole.

[0037]

Moreover, by virtue of the vibration imparting means provided to the ball arraying pallet table, the ball arraying pallet mounted thereon vibrates so that the balls, which were captured by the bottoms or walls of the arraying holes, are separated therefrom.

[0038]

On the other hand, a defective region is skipped, and the balls are sucked from the region where the balls were received in all the arraying holes with the assistance of the image pickup means for monitoring the ball arraying pallet to see whether or not there are balls, whereby a defective product is prevented.

[0039]

Moreover, the images of the sucking plate, semiconductor chip and substrate are taken to monitor them so that it is possible to eliminate defective products.

[0040]

Since the sucking holes are provided for the arraying holes of the ball arraying pallet, while the balls are being arrayed into the ball arraying pallet in the conductive liquid, the flowing paths of the conductive liquid are consistent with the direction in which the balls are received in the arraying holes so that the arraying is smoothly accomplished. Moreover, there is an advantage in that the conductive liquid is evacuated from the sucking holes.

[0041]

[EMBODIMENTS]

Embodiments of the present invention are described with reference to the drawings.

[0042]

(The First Embodiment)

The first embodiment of the present invention is described with reference to figure 1. Figure 1 (a) shows state where a sucking head 1 is over a ball arraying pallet 4 where conductive balls 6 have been arrayed immediately before the conductive balls 6 are sucked to the a ball sucking plate 3, figure 1(b) shows an operation to suck the balls after the ball sucking plate 3 has been tightly held in contact with the ball arraying pallet 4 through the downward motion of the sucking head 1, and figure 1(c) shows state where the balls 6 are disposed on the electrode pads 7 after the sucking head 1, to which the balls have been sucked, are moved to the space over a semiconductor chip 7.

[0043]

The sucking head 1 includes a sucking head base plate 2 and a ball sucking plate 3, and keeps the balls 6 inside of ball sucking holes 31 of the ball sucking plate 3 through the sucking by means of a sucking means, which is not shown, connected to a sucking means connecting port 21.

[0044]

The sucking holes 31 of the ball sucking plate 3 are formed in such a manner as to be aligned with the electrode pads 71 of the semiconductor chip 7 shown in figure 1 (c).

[0045]

Although the ball sucking is carried out through the sucking holes 31 connected to openings 22 and the vacuum sucking path 21, it is not always necessary to make the sucking holes 31 respectively corresponding to the openings 22; however, it is necessary to connect the sucking holes 31 and sucking means to each other in such a manner that the balls 6 are sucked to the sucking holes 31 and sucking means, which is not shown.

[0046]

The ball arraying pallet 4 is formed with arraying holes 41, in which the balls 6 are received, and is placed on a ball arraying pallet table 5 on the condition that the balls have been arrayed in the arraying holes 41.

[0047]

The arraying pattern of the arraying holes 41 is same as the arraying pattern of the electrode pads 71 on the semiconductor chip 7 as shown in figure 1(c). Thus, the arraying holes 41 and sucking holes 31 are laid on the same pattern.

[0048]

In the bottom portions of the arraying holes 41 are formed sucking holes 42 which pass through the ball arraying pallet 4, and the shape and size thereof are determined in such a manner that the balls 6 are received in the bottom portions of the arraying holes 41 without any trouble.

[0049]

The ball arraying pallet table 5 is a table on which the ball arraying pallet is placed, and is formed with air flow paths 51 in such a manner as to be aligned with the sucking holes 42 of the ball arraying pallet 4, whereby the air freely flows into the sucking holes 42 of the ball arraying pallet 4 through the air flow paths 51. However, it is not necessary to make the air holes 52 respectively corresponding to the sucking holes 42 of the ball arraying pallet 4; the air is allowed to flow through the air holes 52.

[0050]

The ball sucking plate 3 and ball arraying pallet 4 are made from a silicon substrate, a metal plate, a glass plate , a ceramic plate or a synthetic resin plate, and is precisely formed through an etching, by way of example.

[0051]

Subsequently, description is made on the sucking/ transferring operation to the semiconductor chip 7.

[0052]

When the ball arraying pallet 5, where the balls 6 have been arrayed, is placed on the ball arraying pallet table 5 on the condition that the sucking head 1 is waiting over the ball arraying pallet 4, the sucking head 1 is moved downwardly, and makes the ball sucking plate 3 brought into tight contact with the ball arraying pallet 4 (see figure 1(b)).

[0053]

Since the lower ends of the sucking holes 31 are hermetically connected to the upper ends of the arraying holes 41, a single air passage is prepared from the openings

22 of the base plate 2 to the sucking holes 42 of the ball arraying pallet 4, and the sucking holes 31 of the ball sucking plate 3 and the arraying holes 41 of the ball arraying pallet 4 are made unity. As a result, the balls 6 are accommodated in the respective spaces, and the interference such as electrostatic attraction is removed therefrom.

[0054]

In this situation, when the sucking means of the sucking head 1 is activated, a high sucking efficiency is achieved because of the narrow objective spaces, and the balls 6 are surely sucked into the sucking holes 31.

[0055]

Since the force, which the airflow passing through the sucking holes 42 gives rise to, is exerted on the balls so as to lift them, the balls, which are captured by the bottoms and walls of the arraying holes 41, are separated therefrom, and are easily sucked into the sucking holes 31.

[0056]

The sucking head 1, into which the balls 6 have been sucked, are lifted together with the balls 6 held therein, are moved to the space over the semiconductor chip 7 as shown in figure 1(c), the sucking holes 31 are aligned with the electrode pads 71, the sucking head 1 is downwardly moved, and the balls 6 are put on the electrode pads 71; thus, the transfer of the balls 6 is accomplished.

[0057]

In case where the balls 6 are pieces of solder, the balls 6 and sucking plate 3 may be concurrently transferred, and are heated in a reflow furnace so as to make the balls melted; while the balls are being melted, or when bump electrodes are produced on the electrode pads 71, the ball sucking plate 3 is eliminated.

[0058]

(Second Embodiment)

Description is made on the second embodiment with reference to figure 2.

[0059]

In this embodiment, the sucking holes 42 of the ball arraying pallet 4 are formed in such a manner as to be offset from the centers of the arraying holes 41 as shown in figure 2(a) and (b).

[0059]

In the arrangement, in which the sucking holes 42 are connected to the centers of the arraying holes 41 as shown in figure 1, if the shape of the sucking holes 42 is circular, the spherical balls 6 is tightly received in the entrances of the sucking holes 42,

and tend not to permit the air to smoothly flow through the sucking holes 42; this reduces the effect of the sucking holes 42.

[0061]

As shown in figure 3(a), the sucking holes 42 are not closed with the balls 6 under the condition that the sucking holes 42 of the ball arraying pallet 4 are offset from the centers of the arraying holes 41.

[0062]

Since the airflow takes place as indicated by arrows in figure 3(a), the air smoothly flows so that the balls 6 are effectively sucked.

[0063]

Moreover, as shown in figure 3(b), in case where the sucking holes 42 are offset from the arraying holes, while the balls 6 are being sucked into the sucking holes 31, the airflow pushes the balls toward the walls of the arraying holes 41, and makes the balls 6 uniformly positioned in the sucking holes 31.

[0064]

When the balls 6 are sucked under the condition that the sucking holes 31 of the sucking plate 3 are offset from the centers of the arraying holes 41 in such a manner that the sucking holes are substantially aligned with the balls 6 forced to the walls after the descent of the sucking head 1, the certainty of the ball sucking is enhanced.

[0065]

If an arraying method, in which the balls 6 are arrayed in the arraying holes 41 of the arraying pallet 3 in liquid, is employed, the sucking holes 42 are not closed with the balls 6 by virtue of the offset of the sucking holes 42 from the arraying holes 41, and there is another advantage in that the liquid is smoothly evacuated from the arraying holes 41.

[0066]

If the balls are made role on the ball arraying pallet 3 inclined in liquid for being received in the arraying holes 41, the liquid smoothly flows by virtue of the sucking holes 42 offset toward the downstream, and the arraying is made easy.

[0067]

For example, the ball arraying pallet 4 formed with the arraying holes 41 for the balls 6 is dipped in a bath filled with the conductive liquid. In this instance, a ball supplying device, which concurrently supplies the conductive liquid and balls 6 onto the ball arraying pallet 3 (though not shown), is prepared.

[0068]

Subsequently, description is made on the sucking operation on the balls 6.

[0069]

As shown in figure 2(b), when the sucking means, which is not shown, starts to suck on the condition that the ball sucking plate 3 is tightly held in contact with the arraying pallet 4 after the descent of the sucking head 1, airflow, which passes through the periphery of the balls 6 into the sucking holes 31, takes place.

[0070]

Since the sucking holes 42 are not clogged with the balls 6, the air smoothly flows as shown in figure 3(a) and 3(b). As a result, even if the balls 6 are captured by the bottoms and walls, the airflow makes the balls 6 released, and the balls 6 are sucked into the sucking holes 31 as they are pressed onto a side surface of each.

[0071]

As shown in figure 3(b), if the sucking head 1 is offset toward the walls on which the balls 6 are pressed in such a manner that the balls 6 pressed to the walls are aligned with the centers of the sucking holes 31, the balls 6 are surely sucked.

[0072]

As shown in figure 3(a) and 3(b), it may be possible to combine a first arraying pallet member 43 formed with the arraying holes 41 with a second arraying pallet member 44 formed with the sucking holes 42. This feature, they are separately formed, is advantageous in that the arraying holes 41 and sucking holes 42 are easily formed as shown in figure 7(a) and figure 7(b). Moreover, it is possible to optimize the diameter of the offset holes and the amount of offset.

[0073]

Since bonding agent such as adhesive compound, which is used in the combination, tends to penetrate into the arraying holes 41 and make the thickness varied, the arraying holes 41 may be not constant in depth. It is desirable to employ a method for directly combine the component members such as, for example, a diffusion bonding.

[0074]

(Third Embodiment)

The third embodiment of the present invention is described with reference to figure 4.

[0075]

The ball arraying pallet 4 shown in figure 4(a) is formed in such a manner that the ratio of the depth of arraying holes 41 to the diameter of balls is fallen within the range from 0.5 to 1.1. When the depth of arraying holes 41 is fallen within the range, the balls 6 are received in the arraying holes 41 in stable, and the balls 6 hardly jump out from the arraying holes 41 due to the vibrations during the travel of the arraying pallet

4. From the viewpoint of the prevention from the jump out, it is more desirable to have the ratio equal to or greater than 0.7.

[0076]

While the balls 6 are being arrayed in the arraying pallet 3 in liquid, the balls, which have been received in the arraying holes 41, are liable to be brought into collision with other balls 6; however, the balls do not jump out from the arraying holes 41 due to the impact of the collision in so far as the depth of the arraying holes 41 are fallen within the range.

[0077]

In order to prevent another ball 6 from the pinch between the arraying hole 41 and the ball already received in the arraying hole 41 as shown in figure 8, it is desirable to be fallen within the range equal to or less than 1.1.

[0078]

Although it is desirable to be less than 1.0 from the viewpoint of prevention from another ball, there is a problem in that the balls 6 are crushed between the ball arraying pallet 4 and the ball sucking plate 3 tightly held in contact therewith.

[0079]

It is possible that escaping holes 35 prevent the balls 6 already received in the arraying holes 41 from the interference with the ball sucking plate 3. The escaping holes 35 has a contour which optimizes the distance between the balls 6 and the end surfaces of the sucking holes 31 for the sucking.

[0080]

It is desirable that the depth of the ball escaping holes 35 ranges from the half of the diameter of the balls 6 plus A to the diameter of the balls 6 plus A. "A" is equal to the clearance between the balls 6 and the ends of the sucking holes 31. It is desirable that A is fallen within the range from 10 % of the ball diameter to 50 % of the ball diameter.

[0081]

Figure 4(b) shows a sucking operation on the condition that the sucking plate 3 is formed in such a manner that the balls 6 are spaced from the ends of the sucking holes 31 by the above-described distance; if the distance is too long, the balls 6 are hardly sucked into the sucking holes 31. On the other hand, it is too short, the balls 6 are not surely sucked into the sucking holes 31, because the they jump at the impact with the sucking holes 31.

[0082]

The present inventors carried out an experience, and found that the distance

between the balls 6 and the sucking holes 31 optimum to the sucking was of the order of 30 % of the diameter of the balls 6.

[0083]

On the other hand, a ball sucking plate table 33 with the sucking holes 31 may be combined with a ball escaping hole plate 34 with the balls escaping holes 35 for forming the ball escaping holes 35 as shown in figure 4.

[0084]

If they are combined with each other by means of bonding agent such as adhesive compound, the bonding agent is liable to penetrate into the sucking holes 31, and the layer of the bonding agent hardly has the constant thickness; this results in the obstacle against the balls 6 sucked thereinto. From this viewpoint, it is desirable to directly combine the component members through the diffusion bonding, by way of example.

[0085]

If the ball escaping holes 35 are formed to be greater in diameter than the arraying holes 41 as shown in figure 9, it is possible to absorb the dispersion in machining accuracy of the ball arraying pallet 4 and the ball sucking plate 3 and the dispersion in the alignment between the ball arraying pallet 4 and the ball sucking plate 3 at the sucking.

[0086]

As shown in figure 10, the ball escaping holes 35 may be formed by plural ball escaping hole plates 34 successively laminated. It is possible to smoothly suck the balls under the condition of the offset, because the contour achieves the effect to guide the balls to the sucking holes 31.

[0087]

The contour of the ball escaping holes 35 may have slopes 36 as shown in figure 11 or have curved surfaces 37 as shown in figure 12.

[0088]

In case where the sloped portion is, by way of example, formed of silicon. In this instance, the sloped portions 36 have (111) plane of silicon.

[0089]

The curved portions 37 may be formed through an electroforming. Otherwise, it is possible to form the curved portions 37 by an organic layer. In this instance, the organic layer is made of at lest one sort of resin selected from the group consisting of polyimide, polyamide and polyurea resin.

[0090]

(The Fourth Embodiment)

The fourth embodiment of the present invention is described with reference to figure 5.

[0091]

A vibration means 8 is connected to the arraying pallet table 5 shown in figure 5. While the vibrating means is vibrating, the ball arraying pallet 4 placed on the arraying pallet table 5 also vibrates. As a result, the vibrations are propagated to the balls 6 received in the arraying holes 41 of the arraying pallet. Even if the balls 6 are captured by the bottom portions or walls of the arraying holes 41, the vibrations causes them to be separated from the bottom portions or walls.

[0092]

The vibration means 8 starts immediately before the balls 6 are sucked or during the sucking operation so as to separate the balls captured by the bottom portions of the arraying holes 41 or walls, and assists the airflow to the sucking holes 42 for separating the balls 6.

[0093]

Although a vibrator, a supersonic vibrating element and a motor are usable as the vibrating means 8, it is desirable to use a piezoelectric element, because it is easily controlled to impart small-amplitude vibrations.

[0094]

(The Fifth Embodiment)

The fifth embodiment of the present invention is described with reference to figure 6.

[0095]

As shown in figure 6, an image pickup device 9 is provided for monitoring the upper surface of the ball arraying pallet 4. The image pickup device 9 monitors a pattern region with which the ball sucking plate 4 is tightly held in contact to see whether or not the balls 6 are surely received in the arraying holes 41; if a trouble takes place in some sucking holes 31, the sucking head skips the region, and is aligned with a completed region so as to prevent it from defective transfer work or from defective products. It is possible to select a completed region where the balls are exactly arrayed by using the monitoring device 9.

[0096]

EFFECTS OF THE INVENTION]

According to the present invention, when the conductive balls are sucked from the ball arraying pallet to the ball sucking plate in vacuum, the ball arraying pallet is

tightly held in contact with the ball sucking plate so that the effect to suck the conductive balls is enhanced.

[0097]

Moreover, the sucking holes are connected to the bottom portions of the arraying holes so as to give rise to airflow around the balls in the sucking work on the balls, and the balls ride on the airflow in order to be sucked to the sucking plate. Thus, the balls are smoothly sucked into the sucking holes.

[0098]

Since the balls are smoothly sucked into the sucking holes, the miniature balls are sucked without any damage, and are transferred to the electrode pads on the substrate.

[0099]

Moreover, since the sucking holes, which are provided under the bottoms of the arraying holes, are disposed in such a manner as to be offset from the arraying holes, the certainty of the sucking work is enhanced because of the stable ball position.

[0100]

Moreover, since vibrations are imparted to the ball arraying pallet table, the balls, which have been captured by the bottoms of the arraying holes and walls, are separated therefrom, and the separation makes the sucking work certain and the efficiency to array the balls enhanced.

[0101]

Since the image pickup means is provided for the ball arraying pallet, it monitors to see whether or not the balls are received, and the balls are not sucked from a defective region but from a region where the balls are received in all the arraying holes so that a defective product does not occur.

[BRIEF DESCRIPTION OF THE DRAWINGS]

[Fig. 1] is a view showing the ball transfer apparatus implementing the first embodiment of the present invention. [Fig. 2] is a view showing the ball transfer apparatus implementing the second embodiment of the present invention. [Fig. 3] is a view showing the structure of the ball arraying pallet and ball sucking plate according to the present invention. [Fig. 4] is a view showing the ball transfer apparatus implementing the third embodiment of the present invention. [Fig. 5] is a view showing the ball transfer apparatus implementing the fourth embodiment of the present invention. [Fig. 6] is a view showing the fifth embodiment of the present invention. [Fig. 7] is a view showing the structure of the ball arraying pallets of the present invention. [Fig. 8] is a view showing the ball arraying pallet of the present

invention. [Fig. 9] is a view showing the contour of the ball escaping holes. [Fig. 10] is a view showing another contour of the ball escaping holes. [Fig. 11] is a view showing yet another contour of the ball escaping holes. [Fig. 12] is a view showing still another contour of the ball escaping holes.

[DESCRIPTION ON REFERENCES]

1 designates the sucking head. 2 designates the sucking head base table. 3 designates the ball sucking plate. 4 designates the ball arraying pallet. 5 designates the ball arraying pallet table. 6 designates the balls. 7 designates the semiconductor chip. 8 designates the vibrating means. 9 designates the image pickup device. 21 designates the sucking means connecting port. 22 designates the opening. 23 designates the vacuuth sucking passage. 31 designates the sucking holes. 33 designates the ball sucking plate table. 34 designates the ball escaping hole plate. 35 designates the ball escaping holes. 36 designates the slopes. 37 designates the curved surfaces. 41 designates the arraying holes. 42 designates the sucking holes. 43 designates the first arraying pallet component member. 44 designates the second arraying pallet component member. 51 designates the airflow passage. 52 designates the air holes. 71 designates the electrode pads.

[DOCUMENT NAME] ABSTRACT

[ABSTRACT]

[PROBLEM] To provide a ball transfer apparatus, which sucks and transfers conductive balls for forming bump electrodes, and which can surely sucks the balls.

[SOLVING MEANS] A ball transfer apparatus, which comprises a ball arraying pallet 4 formed with arraying holes 41 and a ball sucking plate 3, makes the arraying holes 41 hermetically sealed with the ball sucking plate 3 when the balls are sucked from the ball arraying pallet 4 to the ball sucking plate 3.

[SELECTED FIGURE] Figure 1